

Mueller polarimetric imaging as a tool for detecting the effect of non-thermal plasma treatment on the skin: supplement

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Mueller Polarimetric Imaging as a new tool for detecting the effect of Non-Thermal Plasma treatment on the skin

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Supplementary material

The temperature in the central area (in direct contact with the plasma jet) of 3 skin samples treated with a 1.0 W power plasma jet was monitored for 2 minutes, as shown in Fig. S1. The temperature increased rapidly during the first 20 seconds and became stable after about 40 seconds for all samples. The temperature difference between the 3 samples was less than 2°C after 2 minutes. The final steady state temperature was found to be dependent on the plasma power. Indeed, it reached 45°C, 55°C, 63°C, and 73°C with plasma power of 0.5 W, 0.8 W, 1.0 W, and 1.4 W, respectively (not shown).

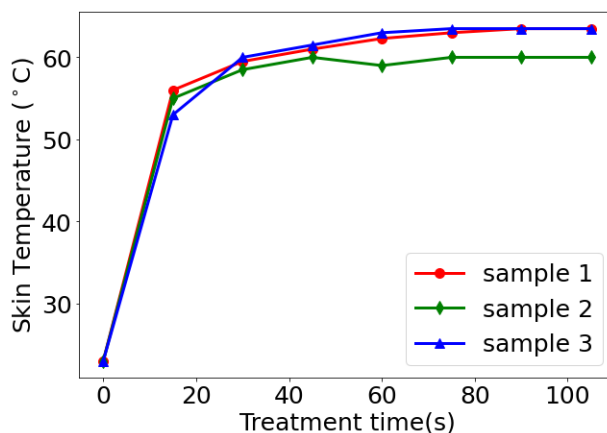


Fig. S1. Maximum temperature of the area irradiated by 1W plasma jet as a function of treatment time for three pig skin samples.

Fig. S2 shows the surface temperature of a pig skin sample treated with a 1 W plasma jet. The temperature is measured by an infrared camera. In particular, the maximum temperature of 62.1°C is reached in the central part of the treated area marked by the red cross. A radial temperature gradient is formed from the central part of the treated area towards the more peripheral areas where the temperature remains around 22°C (room temperature).

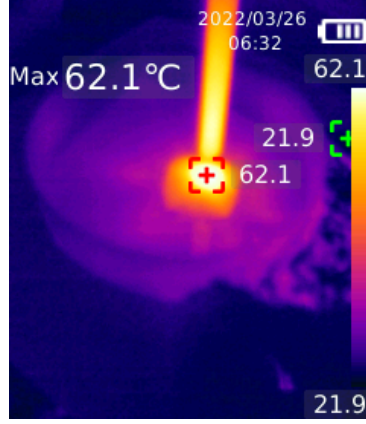


Fig. S2. The temperature distribution on the surface of a skin sample during plasma treatment, measured by the infrared camera. The plasma power is 1 W. The image resolution is 220×192 pixels.

Fig. S3 shows the unpolarized intensity image (unnormalized M11 coefficient of Mueller matrix), the linear retardance LR, and the total depolarization Δ of a skin sample measured three times continuously. The skin sample was soaked for 20 min before starting measurements, but was not treated with plasma. The time required for each measurement was less than 1 min. As a reminder, the light flow increases the temperature of the skin sample from $21.7 \pm 0.4^\circ\text{C}$ (room temperature) to $22 \pm 0.4^\circ\text{C}$ after 10 min. The mean value of the linear retardance μ_{LR} and the total depolarization μ_{Δ} , calculated for all pixels of the sample surface, are shown above each corresponding image. No significant difference is observed between the three measurements. This result shows that the illumination of the MPI does not generate any significant change during the acquisition of polarimetric images.

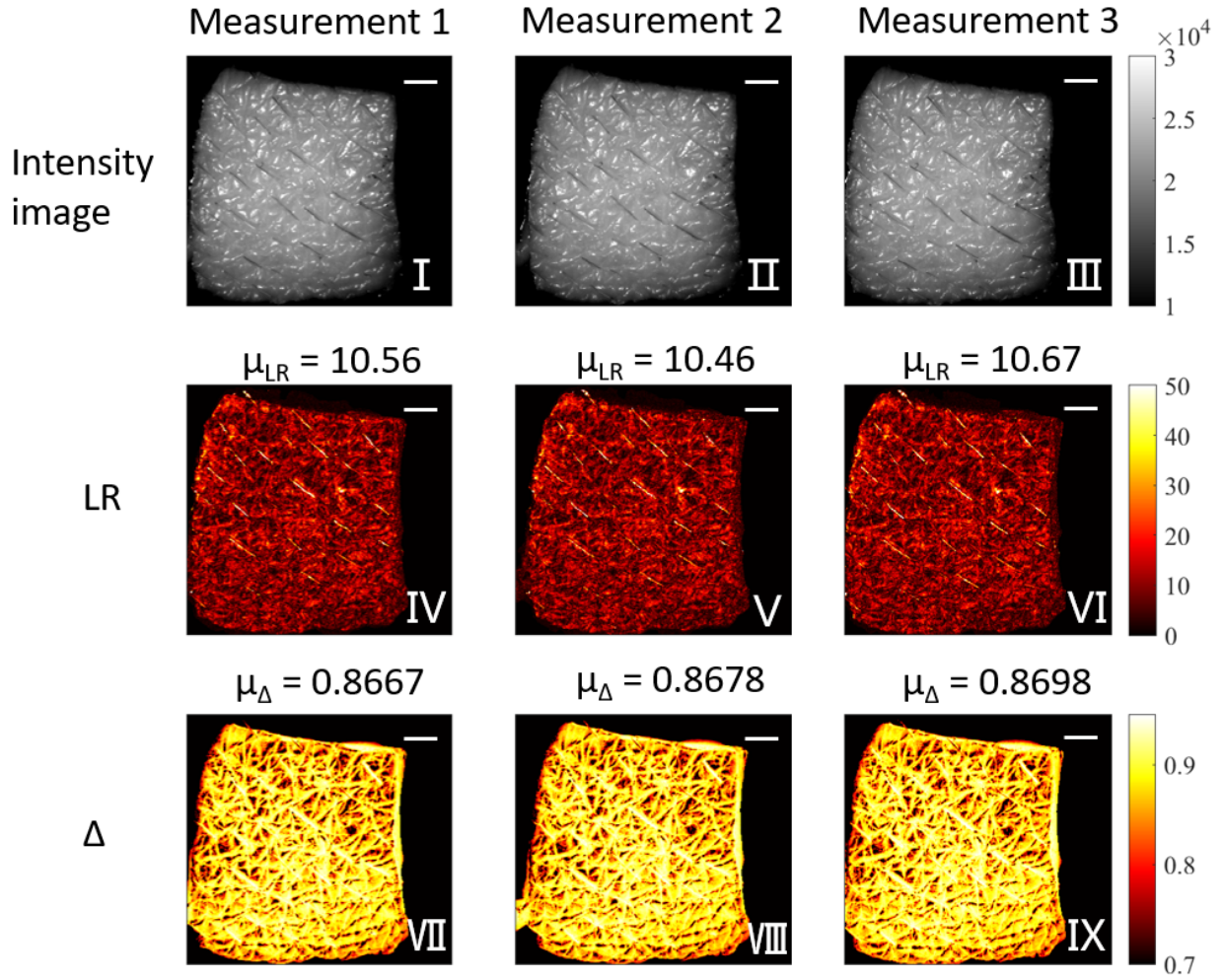


Fig. S3. The Intensity image, the linear retardance, and the total depolarization of a skin sample measured three times continuously. The skin sample is soaked for 20 min but not treated by plasma before the measurement. Scale bars: 2 mm.

In addition to the linear retardance and the total depolarization, other polarimetric parameters were investigated, such as the azimuth of the slow axis of the linear retardance and the total diattenuation.

The azimuth of the slow axis of the linear retardance is calculated by the following formula:

$$\alpha = \frac{1}{2} \arctan\left(\frac{\mathbf{M}_{R24}}{\mathbf{M}_{R43}}\right)$$

where \mathbf{M}_{R24} and \mathbf{M}_{R43} are elements of the \mathbf{M}_R matrix. In order to reduce the recurrent jumps in the colormap of the azimuth images, thus simplifying their visual interpretation, the range of variation of this parameter has been extended between 0° and 180° [1].

The total diattenuation \mathbf{D} is calculated by the following formula:

$$\mathbf{D} = \frac{\sqrt{\mathbf{M}_{D12}^2 + \mathbf{M}_{D13}^2 + \mathbf{M}_{D14}^2}}{\mathbf{M}_{D11}}$$

where \mathbf{M}_{D12} , \mathbf{M}_{D13} , and \mathbf{M}_{D14} are elements of \mathbf{M}_D matrix normalized with respect to the unnormalized \mathbf{M}_{D11} element.

No significant reproducible effects due to the plasma treatment under the different conditions considered were observed from these parameters. Fig. S4 shows, as an example, the total diattenuation and the azimuth for the same pig skin sample presented in Fig. 5 of the article. As a reminder, location L1 is treated with 0.3 W plasma and location L2 is treated with 1 W plasma. The treatment time for each location is 4 minutes. No difference can be observed in the total diattenuation before and after treatment. The azimuth shows a slight difference at location L2, which indicates a change in the orientation of the fiber structures in this area. However, the observed change is rather random and not reproducible.

Thus, only the linear retardance and the total depolarization are presented in the paper because they allow the observation of highly reproducible effects.

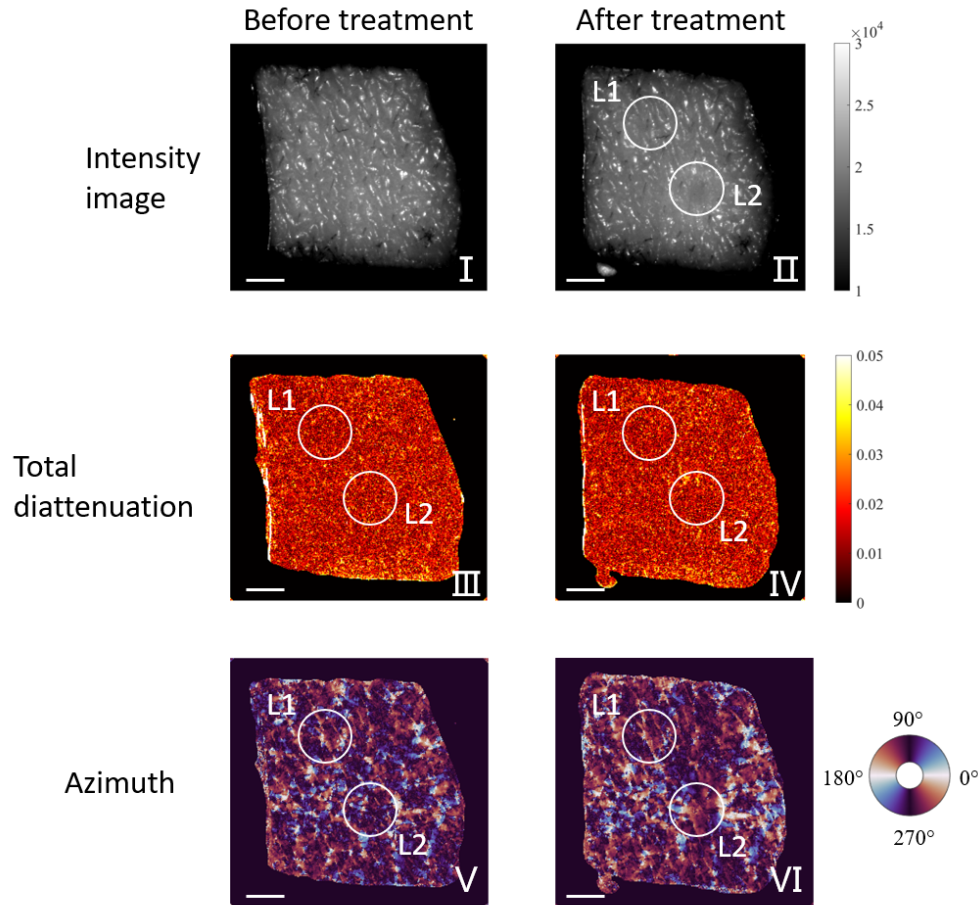


Fig. S4. The intensity image (I, II), total diattenuation (III, IV), and the azimuth (V, VI) of a skin sample before plasma treatment (left column) and after plasma treatment (right column). Location 1 (L1) and 2 (L2), marked as white circles in II, were treated with 0.3 W and 1 W plasma for 4 min, respectively. The skin reached a maximum temperature of 35°C and 63°C at L1 and L2, respectively. Scale bars: 2 mm.

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